First Workshop on marine mollusc communities of the Mediterranean. R. Chemello & G.F. Russo (eds)
Bollettino Malacologico, Roma, **33** (5-8): 69-76, [1997]1998 - Società Italiana di Malacologia

The Molluscan assemblage of the leaf stratum in a *Cymodocea nodosa* bed of a marine coastal lagoon

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KEY WORDS: Mollusc, *Cymodocea nodosa*, Marine lagoon, Mediterranean.

ABSTRACT The malacofauna of the leaf stratum in a *Cymodocea nodosa* bed in the "Stagnone di Marsala" lagoon (Western Sicily) has been used as an ecological descriptor of this coastal system. The results indicate a relative temporal homogeneity in the assemblage, with a few differences due to the demographic explosions of Rissoids during the spring. The distribution of the species in the basin is related to a particular hydrodynamic gradient caused by surface currents.

RIASSUNTO La malacofauna di strato foliare di una prateria di *Cymodocea nodosa* in una laguna mediterranea.
Viene descritta la distribuzione del popolamento a molluschi di strato foliare di una prateria a *Cymodocea nodosa* dello Stagnone di Marsala (Sicilia occidentale). Questo studio si inserisce nel tentativo di inquadrare il popolamento a molluschi dello Stagnone nell'ambito di uno schema zonale, individuando i fattori che ne governano la strutturazione. Dai risultati emerge che il popolamento a molluschi rimane piuttosto stabile nel tempo, anche se la stagionalità sembra influenzare le abbondanze di alcune specie di Rissoidi. La malacofauna mostra, infine, una buona correlazione con il modello idrodinamico dell'area studiata, senza apprezzabili differenze tra le diverse stazioni legate a fenomeni di confinamento.

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INTRODUCTION

Numerous studies have been carried out on the malacofauna of the foliar stratum of *Posidonia oceanica* beds (e.g. RUSSO *et al.*, 1984a, 1984b, 1991a, 1991b) with the aim of describing the structure of the assemblages during the annual cycle or during their diel variations, while less is known about the molluscs associated with the other Mediterranean phanerogam, *Cymodocea nodosa* (Ucria) Aschers (SCOTTI *et al.*, 1995).

This small marine plant lives on sandy and sandy-muddy bottoms both in lagoon and open-sea habitats. Bionomically it belongs to the SVMC biocoenosis (muddy bottoms in calm waters) of the PÉRÈS & PICARD (1964) system and can form dense plots called "turf" (BUIA *et al.*, 1985), of wover rhizomes and sediment. In the "Stagnone di Marsala", a shallow marine lagoon along the western coast of Sicily, *Cymodocea nodosa* prairies cover about 70% of the sea bottom (CALVO *et al.*, 1980; 1982), either in a pure facies or in a mixed assemblage with *Caulerpa prolifera* or *Zostera noltii*.

Regarding the malacofauna of this basin, a number of studies have recently been carried out describing the taxonomic composition of this *taxon* (CATTANEO-VIETTI & CHEMELLO, 1992; CHEMELLO & RIGGIO, 1991a, 1991b). The relationships between molluscan communities and nature conservation have also been examined (TUMBIOLO *et al.*, 1992).

MATERIALS AND METHODS

Study area

The "Stagnone di Marsala" is a large marine lagoon (*sensu* MOLINIER & PICARD, 1953) which extends for 7 Km along a north-south axis off the western coast of Sicily (Fig. 1). It can be divided into two different basins: the first, more southerly, basin has a large exchange of water with the open sea, and the second, more northerly, one has more marked lagoon characteristics and, with its shallow bottom, presents three islets and a number of superficial bioformations which regulate the hydrodynamic pattern.

The bottoms of the northern basin are mainly sandy and sandy-muddy (AGNESI *et al.*, 1993) and are covered by dense meadows of *Cymodocea nodosa*. Hard calcarenitic bottoms are relatively scarce. *Posidonia oceanica* meadows also appear in the southern part of the basin with singular "recif" and "atoll" formations (CALVO & FRADÀ-ORESTANO, 1984).

Hydrological exchange with the open sea occurs through two mouths of different widths which produce a particular current scheme characterized by oscillating and whirling motions. According to a theoretical model (DI PISA & RIGGIO, 1982), water circulation can be linked to a laminar flux regulated by the tides and winds, above all those coming from the north and north-west (Fig. 2).

Sampling techniques

Sampling was performed during one year in 6 stations (Fig. 1), along a hypothetic al N-S and E-W hydrodynamic gradient. The samples were collected seasonally on *Cymodocea nodosa* meadows with a percent age cover of about 100% of the total surface, using a standard hand-towed net (RUSSO *et al*, 1986; RUSSO & VINCI, 1991) on a 20m length transect. This distance was obtained from the rarefaction curve of the area/species ratio (Fig. 3).

Data analysis

The raw data were inserted in a sample/species matrix. Descriptive analysis was performed by considering the quantitative dominance of species (1-D), the Shannon index of diversity (H')

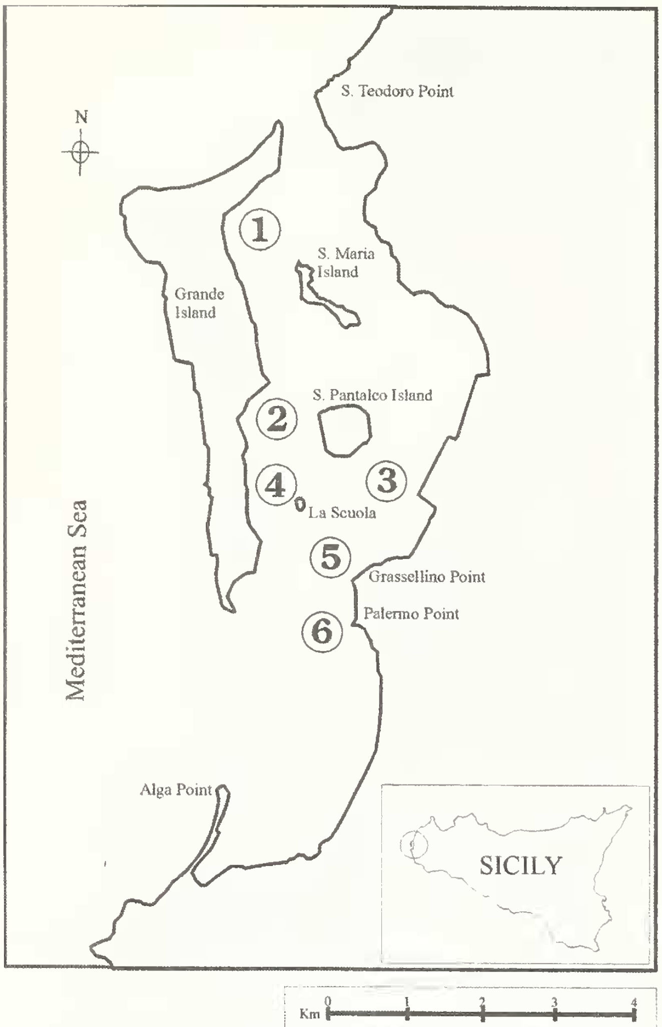

Figure 1. The Stagnone di Marsala lagoon with the stations of sampling (1-6).

and the evenness (J) for each sample; the Dajoz index of frequency (Fr%) and the Glemarec index of total dominance (Dt%) were calculated for each species. The first index (Dajoz, 1971) separates the species into frequency classes: the *taxa* with a frequency of occurrence 100>Fr%>76 are defined as "constant"; the species with 75>Fr%>51 are considered "very common"; with 50>Fr%>26 area "common" and with 25>Fr%>12 "less common". Finally, the species with Fr%<12 are defined as "rare".

Prior to carrying out the structural analyses, the "rare" species were excluded from the matrix. "Rare species" were considered those present only once with one individual. *Pusillina* spp. juv and *Rissoa* spp. juv were also excluded as these *taxa* were composed of species which in practice were undistinguishable from each other.

Structural analysis, based on the time series of samples, was performed by cluster analysis using the Jaccard index on a presence/absence matrix while the ^{2} index was applied on the semi-quantitative data matrix (Pielou, 1984). Both matrices were clusterized using the UPGMA technique. Multivariate correspondence analysis (Benzecrì, 1973; Legendre & Legendre, 1971) was carried out to determine structure, and the significance of the axes was tested using the method of Frontier (1976).

RESULTS AND DISCUSSION

A total of 17466 individuals belonging to 53 species of foliar stratum were found. The dominant *taxa* were the Gastropods, with 52 species, and the Bivalves, which were present with only one species, *Parvicardium exiguum*, associated with the lower part of *Cymodocea nodosa* leaves. Among the gastropods, Naeotaenioglossa was the dominant order, with the 35.8% of the total number of species, followed by Neogastropoda (24.5%), Heterostropha (13.2%) and Vetigastropoda with 11.3%. All the other orders together reached only 15.1% (Fig. 4).

Using the constancy index of Dajoz (Tab. 1a), only 13 species were considered "constant", with a high frequency of occurrence in the assemblage: *Tricolia speciosa*, *Granulina occulta*, *Pusillina dolium*, *Columbella rustica*, *Pusillina marginata*, *Vexillum tricolor*, *Ocinebrina aciculata*, *Retusa truncatula*, *Rissoa paradoxa*, *Nassarius costulatus*, *Haminoea hydatis* and *Parvicardium exiguum*. A second group was composed of *Conus mediterraneus*, *Gibbula ardens*, *Cerithium vulgatum* and *Rissoa similis*, all "very common" species in the assemblage. *Vexillum ebenus*, *Alvania cimex*, *Haminoea* sp., *Pisinna glabrata*, *Chrysallida nanodea*, *Alvania pagodula*, *Tragula fenestrata* were "common". The other taxa did not reach significant constancy values and 20 were "rare" species.

The highest value of total dominance (Tab. 1b), according to

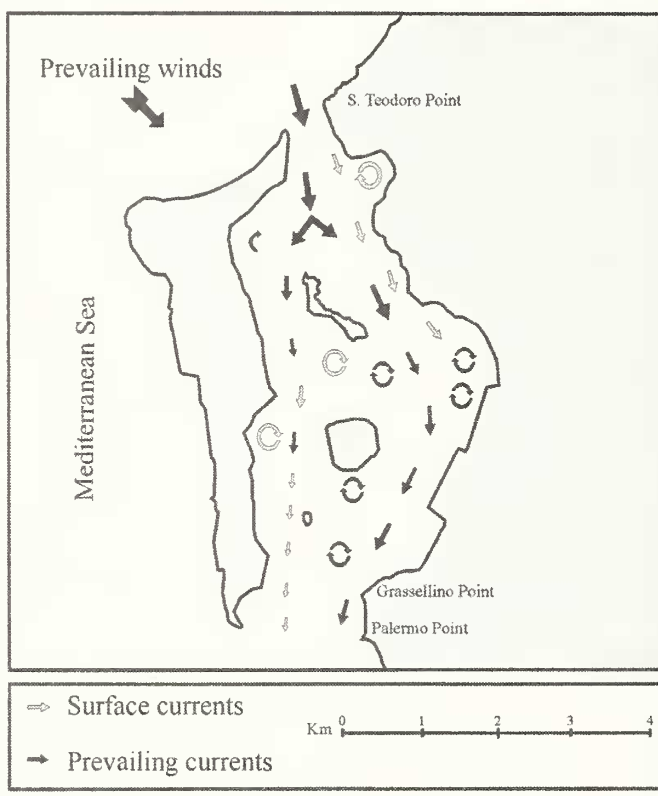

Figure 2. The hydrodinamic model of surface currents (from Di Pisa & Riggio, 1982, slightly modified).

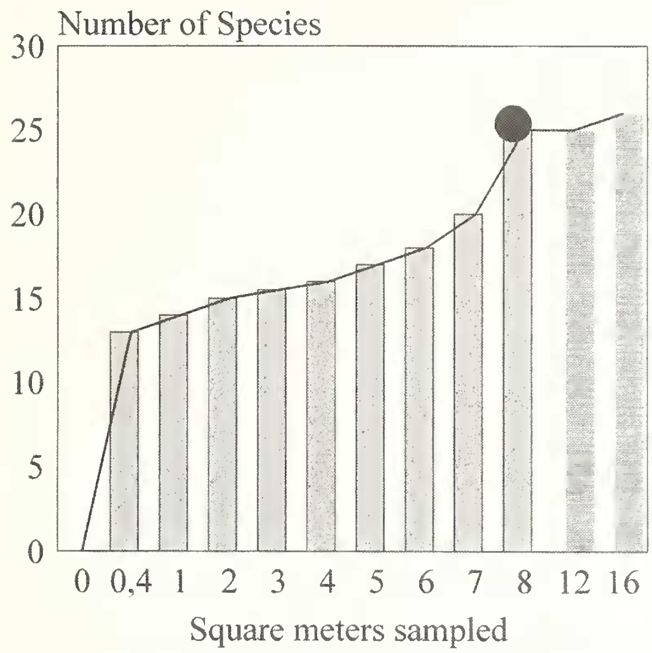

Figure 3. Rarefaction curve of sampling area/number of species ratio.

the Glemarec index, was obtained by *Pusillina marginata*, followed, with a lower value, by *Granulina occulta*, *Pusillina dolium* and *Tricolia speciosa*.

Seasonality biased the relative abundances of some species, above all *Pusillina marginata* and *P. dolium*, which were the dominant species during spring and summer, *Gibbula ardens*, which was dominant in the spring and summer samples of station 1, and *Setia turriculata*, present only in the spring sample of station 1.

Plots of the seasonal values of H'-J and D-E (Fig. 5-6) indicate an overall homogeneity during the year, with a constant decrease between summer and winter in the samples in which the low diversity is due to the high specific dominance of a small number of species present with a large number of individuals.

The cluster analysis on the presence/absence matrix, carried out using the similarity index of Jaccard, shows a homogeneous group of samples without marked differences in composition (Fig. 7). The second cluster analysis on quantitative data, using ^{2}, separates samples of the station 1 from the other stations (Fig. 8).

The FAC on qualitative data (Fig. 9) presents only one significant axis (explained variance = 14.2% of the total). The distribution of the sample-points in the F1-F2 plane is similar to that in the graphic model called "circular cloud" proposed by FRESI & GAMBI (1982) and testifies to the homogeneity of the assemblage, due to the species composition.

The FAC on quantitative data (F1= 32.7%, F2= 18.8%, F3= 12.1% of the total variance) ordinates the sample-points in three separate groups in the F1-F2 plane(Fig. 10a): the first includes all the samples of station 1; the second gathers together all the spring samples (2P, 3P, 4P, 5P, 6P); the third group assembles all the remaining samples. On the F1-F3 plane (Fig. 10b) only the samples of station 1 are separated from the others, while 3I and 5I clusterize separately.

In this tridimensional system, the F1-axis can be interpreted as an open-seainner lagoon gradient while the F2 axis is probably a seasonal gradient due to the rearrangement of specific abundances more than to a change in the species composition of the assemblage. The F3-axis is more complex to identify.

To highlight the development of the principal gradient, the barycentres of the sample-points were projected on the F1 axis (Fig. 11 above). This arrangement indicates a marked polarization in the negative part of the first axis of the samples collected from stations 2-6. This is due to the high variance inherent to station 1 very different in composition to the others. This station can be, in fact, considered "open-sea"-like due to its position near the northern mouth, in a more vivified area. This model separates two sub-basins, the first, more northerly, and the second in the central area, distinguished by the ir different hydrodynamic conditions (MAZZOLA & SARÀ, 1995). The hydrodynamic pattern of the surface currents seems again to be the principal factor conditioning the distribution of the species.
In order to show these differences in species distribution or their belonging to one or more assemblages, the barycentres with the species-points were reported on the F1 axis, in comparison of

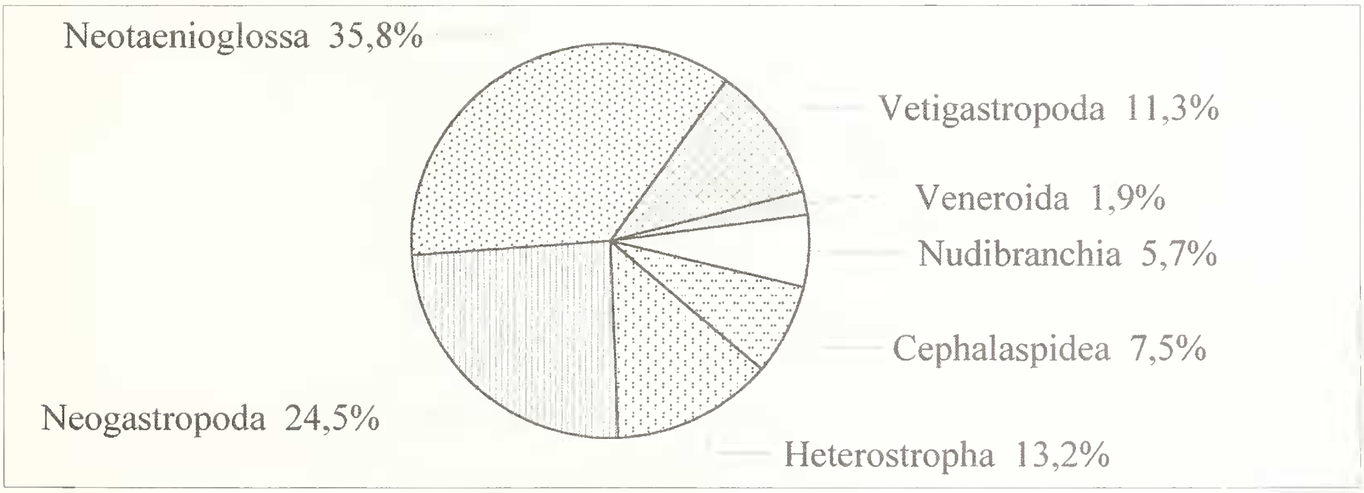

Figure 4. Distribution of the sampled species in orders.

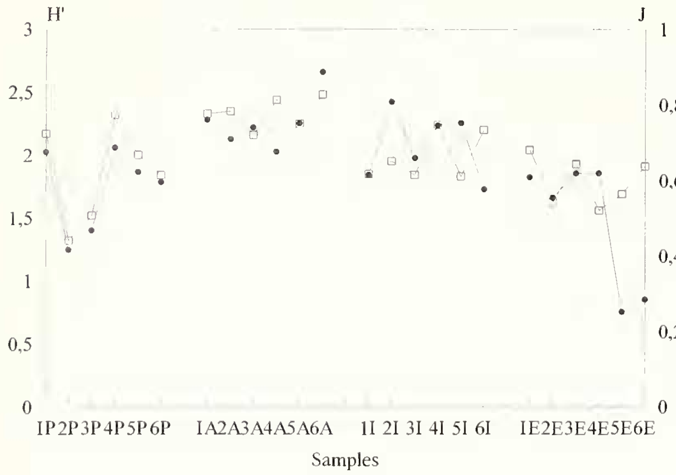

Figure 5. Shannon-Wiener diversity indices and their evenness.
The open quadrats mean the values of the Shannon index while the black dots mean the relative values of the evenness.

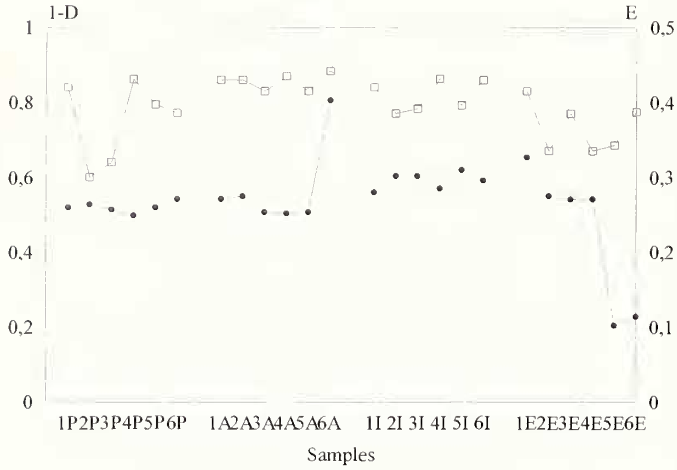

Figure 6. Simpson diversity indices and their evenness.
The open quadrats mean the values of the Simpson index while the black dots mean the relative values of the evenness.

the distribution of the sample-points (Fig. 11, below). Three different groups of species are evidenced: the first is related to the single 1P sample in which some exclusive species are present. The second cluster collects the samples 1E-1A-1I and the third cluster all the remaining samples. The strong polarization of this third group of samples is partially due to a bias in the ordination technique that gives more weight to the species- or sample-points which explain the major part of the system variance. The species further away from the origin of the axes are the exclusive or dominant species in single samples and these can be related to seasonality or, better, to the development of the predominant factor.

The species belonging to the first group are: *Setia turriculata*, *Gibbula ardens*, *Peringiella elegans*, *Dikoleps nitens* and *Barleeia unifasciata*, strictly associated with the *Cymodocea nodosa* prairie of sample 1P. The second group is composed of: *Bittium latreillii*, *Hexaplex trunculus*, *Vexillum tricolor*, *Haminoea hydatis*, *Cerithium vulgatum*, *Nassarius costulatus*, *Ocinebrina aciculata*, *Tricolia speciosa*. All these species are present in more or less all the samples and constitute the "fundamental group" of species associated with the leaf stratum in this area. The third cluster assembles all the species living in the inner part of the Stagnone, present during the year with low abundances and without demographic explosions. The continuity among groups and the low values of scores do not allow the recognition of more than one assemblage.

CONCLUSIONS

The model of distribution obtained from the malacofauna of the *Cymodocea nodosa* leaf stratum in the Stagnone shows a species zonation mainly related to the hydrodynamic pattern (Fig. 12), hence to an inverse gradient of "vivification" (SACCHI, 1959) or "marinization" (ZAOUALI & BAETEN, 1983) from the northern mouth to the inner part. The assemblage of station 1 differs throughout from that of the other stations and presents a high number of species more akin to the open-sea assemblage, like *Gibbula ardens* e *Setia turriculata*.

The inner area of the Stagnone presents an annually-stable malacofauna, composed of marine species which are well adapted to a more lagoon-like environment (TUMBIOLO *et al.*, 1991). This assemblage, annually homogeneous in its species composition, presents a reduced temporal drift due solely to the spring demographic explosions of *Pusillina marginata* and *P. dolium*.

The faunistic coenocline presented by other lagoons, which is characterized by the progressive exclusion of marine *taxa* (GRAVINA *et al.*, 1988), is less evident in the Stagnone of Marsala. In particular, the peculiar morphological structure of the basin and its wide relationship with the open sea do not allow the formation of a paralic assemblage *sensu stricto* but of a malacofauna quite reophilous in the northern part and quite galenophilous in the inner part, respecting the general scheme suggested by BIANCHI (1985; 1988).

The hydrodynamic model proposed by DI PISA & RIGGIO (1982) and reviewed by MAZZOLA & SARÀ (1995) seems to be confirmed by the distribution pattern of the malacofauna of the foliar stratum.

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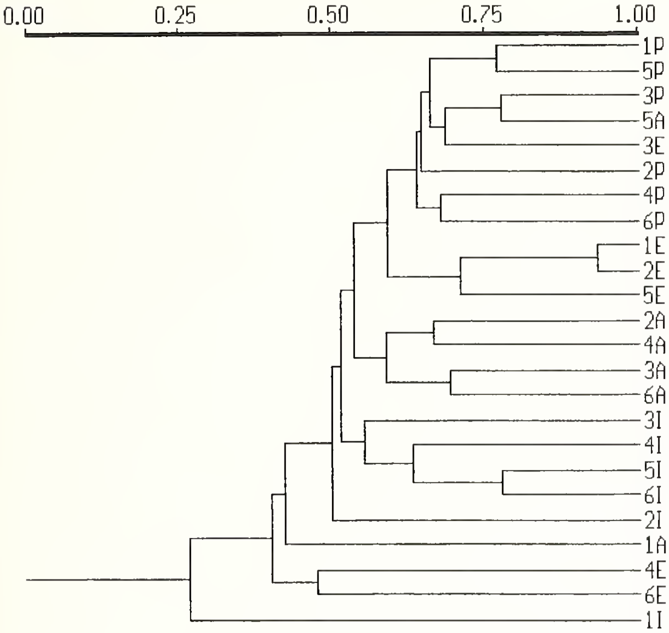

Figure 7. Dendrogram of the samplings, using Jaccard index and UPGMA clustering method.

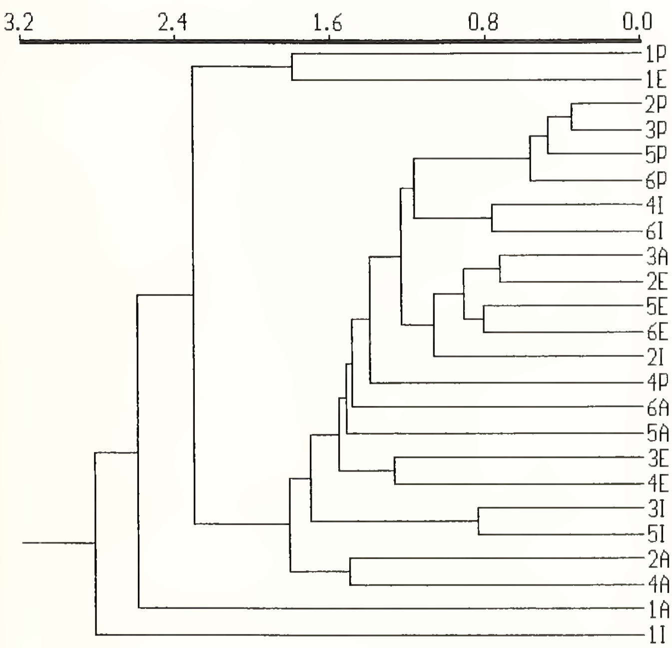

Figure 8. Dendrogram of the samplings, using ^{2} index and UPGMA clustering method.

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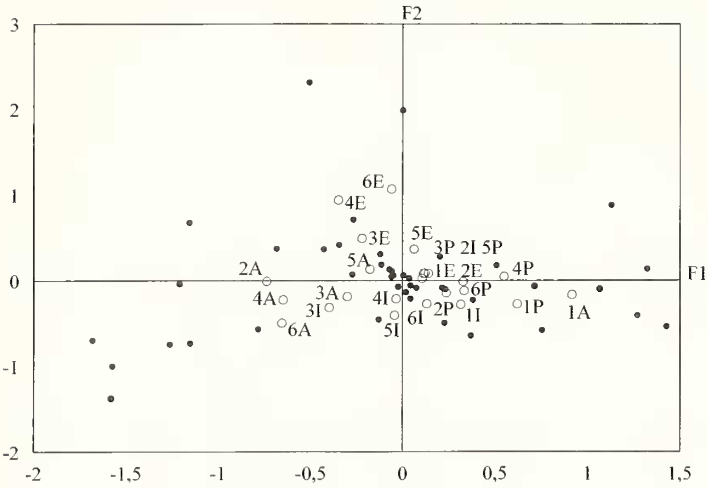

Figure 9. Factorial Correspondence Analysis on the presence/absence data.

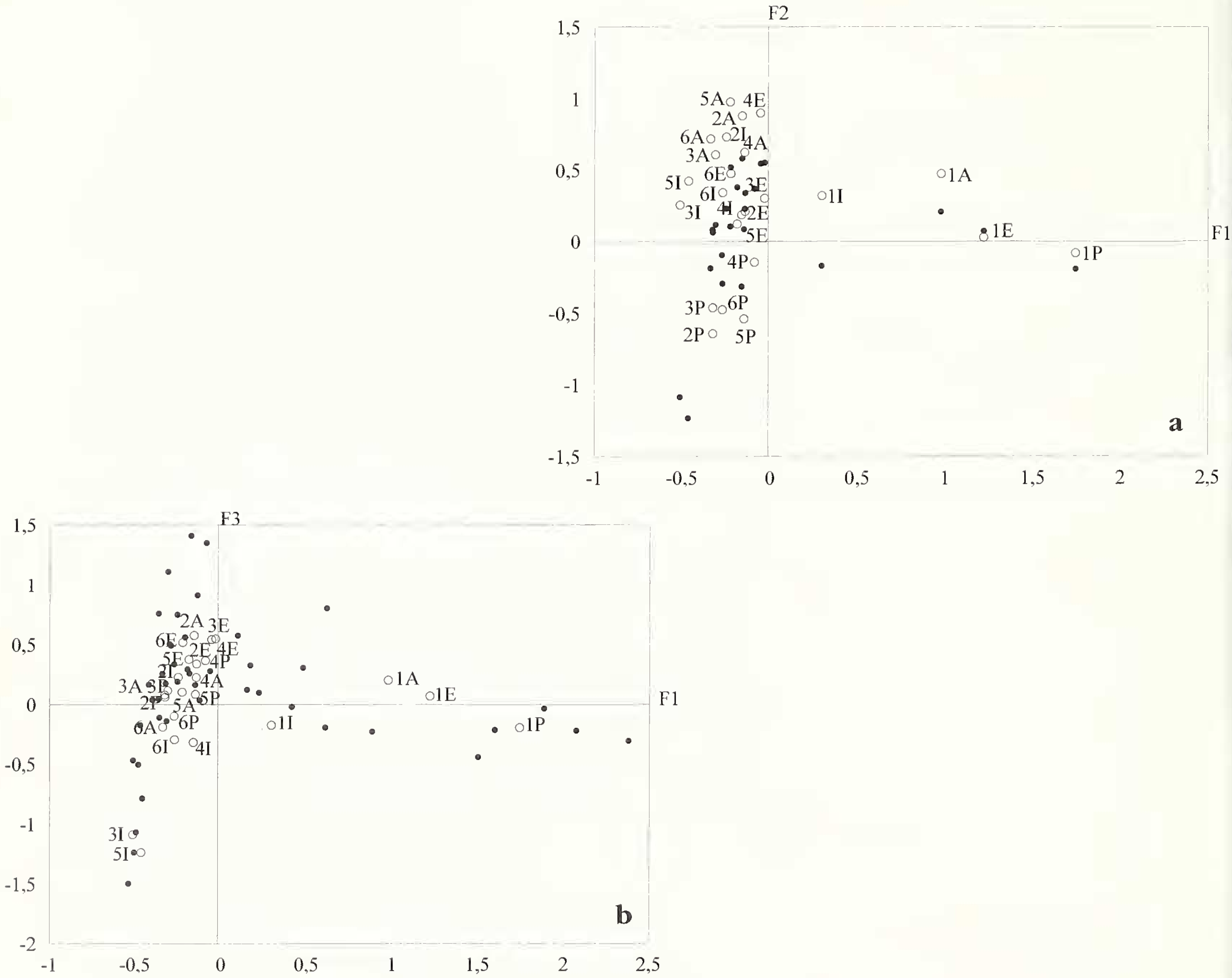

Figure 10a-b. Factorial Correspondence Analysis on the abundance data.
Fig. 10a is relative to the F1-F2 axis plan while
Fig. 10b th the F1-F3 axis plan.

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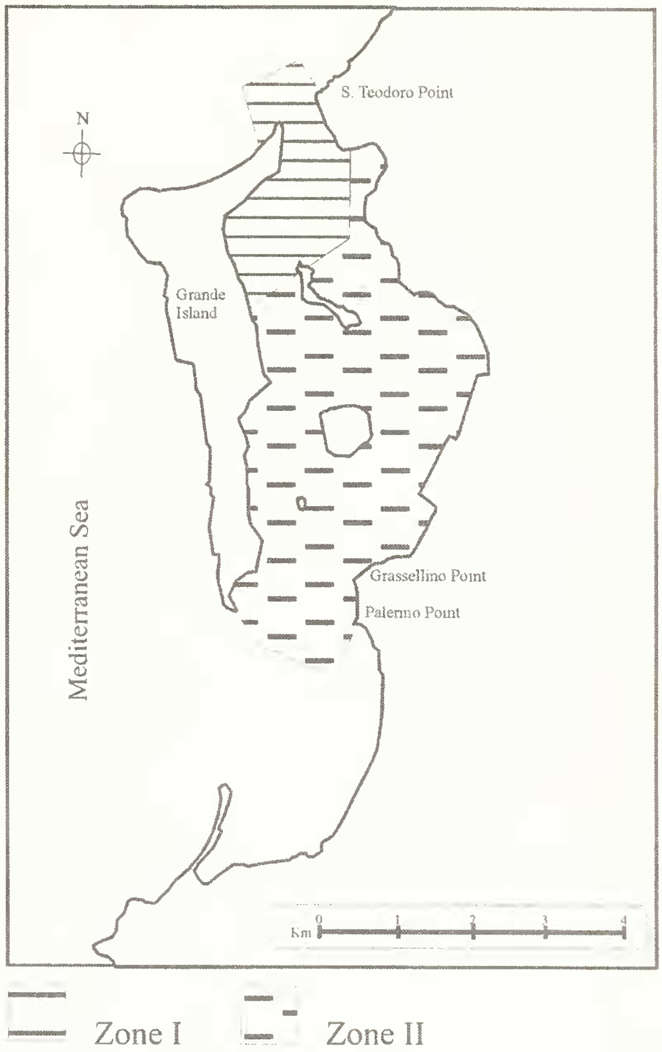

Figure 12. Model of the species distribution.

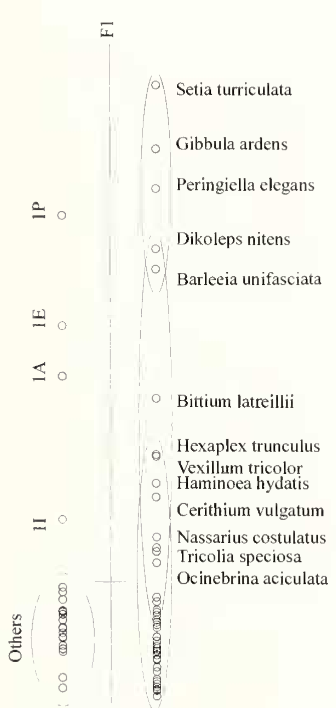

Figure 11. Barycentres of the species and the samples plotted on F1 axis.

Lavoro accettato il 7 Marzo 1998

	Fr%
Tricolia speciosa	100
Pusillina dolium	95,83
Columbella rustica	95,83
Granulina occulta	95,83
Pusillina marginata	91,67
Ocinebrina aciculata	91,67
Vexillum tricolor	91,67
Rissoa paradoxa	87,5
Retusa truncatula	87,5
Nassarius costulatus	83,33
Haminoea hydatis	83,33
Parvicardium exiguum	79,17
Conus mediterraneus	66,67
Gibbula ardens	62,5
Cerithium vulgatum	62,5
Rissoa similis	54,17
Vexillum ebenus	50
Alvania cimex	45,83
Haminoea sp.	45,83
Pisinna glabrata	41,67
Chrysallida nanodea	37,5
Alvania pagodula	33,33
Tragula fenestrata	29,17
Dikoleps nitens	25
Bittium latreillii	25
Barleeia unifasciata	25
Rissoella globularis	25
Odostomia plicata	25
Chrysallida sp juv	20,83
Peringiella elegans	16,67
Odostomia sp juv	16,67
Setia turriculata	12,5
Nodulus contortus	12,5
Hexaplex trunculus	12,5
Runcina sp.	12,5
Pollia scabra	8,333
Gibberula philippii	8,333
Raphitoma purpurea	8,333
Anisocycla pointeli	8,333
Hypselodoris messinensis	8,333
Polycera dubia	8,333
Sinezona cingulata	4,167
Calliostoma laugieri	4,167
Jujubinus striatus	4,167
Pirenella conica	4,167
Rissoa sp.	4,167
Alvania discors	4,167
Truncatella subcylindrica	4,167
Nassarius corniculus	4,167
Mangelia costulata	4,167
Aeolidiidae ind.	4,167

Table 1a. Frequency of occurrence for each species, according to the Dajoz Index.

	Dt%
Pusillina marginata	27,42
Granulina occulta	14,72
Pusillina dolium	13,85
Tricolia speciosa	13,42
Gibbula ardens	5,495
Retusa truncatula	4,598
Vexillum tricolor	2,854
Columbella rustica	2,265
Nassarius costulatus	2,092
Setia turriculata	1,485
Rissoa paradoxa	1,446
Haminoea hydatis	1,35
Cerithium vulgatum	1,253
Conus mediterraneus	0,819
Parvicardium exiguum	0,771
Alvania cimex	0,684
Ocinebrina aciculata	0,665
Rissoa similis	0,588
Odostomia plicata	0,588
Odostomia sp juv	0,366
Dikoleps nitens	0,357
Haminoea sp.	0,337
Peringiella elegans	0,299
Vexillum ebenus	0,251
Pisinna glabrata	0,241
Chrysallida nanodea	0,241
Alvania pagodula	0,231
Runcina sp.	0,222
Barleeia unifasciata	0,193
Tragula fenestrata	0,164
Chrysallida sp juv	0,135
Rissoella globularis	0,116
Bittium latreillii	0,087
Alvania discors	0,067
Nodulus contortus	0,048
Hexaplex trunculus	0,039
Gibberula philippii	0,029
Raphitoma purpurea	0,029
Sinezona cingulata	0,019
Pollia scabra	0,019
Mangelia costulata	0,019
Anisocycla pointeli	0,019
Hypselodoris messinensis	0,019
Polycera dubia	0,019
Calliostoma laugieri	0,01
Jujubinus striatus	0,01
Pirenella conica	0,01
Rissoa sp.	0,01
Truncatella subcylindrica	0,01
Nassarius corniculus	0,01
Aeolidiidae ind.	0,01

Table 1b. Total dominance for each species, according to the Glemarec Index.